MAGNETIC REVERSAL SPURTS: RAIN GAUGES FOR COMET SHOWERS?; T.M. Lutz, Dept. of Geology, University of Pennsylvania, Philadelphia, PA 19104-6316

Abrupt increases in the rate of magnetic reversals (magnetic reversal spurts) were first studied by Pal and Creer (1). They hypothesized that spurts result from increased turbulence in the earth's core dynamo during episodes of intense bolide bombardment of the earth. Muller and Morris (2) suggested a physical mechanism that could explain how the impact of a large bolide could affect the state of the core. They also summarized evidence supporting the idea that some individual magnetic reversals are associated with impacts. According to their theory, a reversal would occur within 10^4 y of an impact. Other direct and indirect effects of impacts, such as mass extinctions, climatic effects, and sea level changes, would occur within the same interval. Over most of the geologic time scale an impact and its consequences within such a short interval can be considered simultaneous.

Mechanisms for creating episodes of intense bombardment of the earth involve gravitational perturbation of the Oort cloud of comets, either by a hidden planet, a solar companion, or massive matter in the galactic plane. The periods of bombardment would have a duration of about 3 m.y., during which the earth might experience multiple impacts (3). Multiple impacts could explain the stepwise character of mass extinctions. Consequently, both mass extinction episodes and magnetic reversal spurts might have a duration equal to the length of a comet shower, or about 3 m.y.

A 15-m.y. rectangular moving window was used to reveal variations in the reversal rate in the original study (1). This window is too wide to be sensitive to spurts that might be only 3 m.y. long. Some frequency histograms of the magnetic reversal record using narrow bins (8.3-m.y. (4); 5-m.y. (1,5); 4-m.y. (6)) show spurt-like peaks in reversal rate. However, these studies (4-6) were not designed to detect spurts and the meaning of the peaks is ambiguous because some variables were not controlled. For example, the positioning of the bins, which plays a role in the appearance of the histogram, was not taken into account.

In this paper, the time variation in reversal rate is analyzed using methods of statistical density estimation (7). A smooth, continuous estimate of reversal rate is obtained using an adaptive kernel method, in which the kernel width is adjusted as a function of reversal rate. The estimates near the ends of the data series (at 165 m.y. ago and the present) are obtained by extending the data by reflection.

The results of analyzing the Harland et al. record (8) show that rapid increases in the reversal rate occurred repeatedly and that the durations of these spurts ranged from 1 m.y. to 5 m.y. The spurts terminate by a rapid decrease in rate to levels characteristic of activity before the spurt. In one case, a double peak suggests that two spurts occurred in rapid succession.

Kernel methods, like some moving windows, create an interpretive problem because the resulting smooth reversal rate curve gives the impression of more information than actually exists (9). To determine whether the spurts are actually likely to contain information about the short-term variation in reversal rate, simulated reversal records were generated. The simulations were based on a long-term variation model (10) so that rate fluctuations on the 1-5 m.y. time scale were sure to be random. Adaptive kernel analyses of the simulations show that spurts similar in amplitude, width, and shape to those found in the Harland et al. record are also typical of the simulations.

One interpretation of these results is that no explanation other than random fluctuations superimposed on the long-term change in reversal rate is required to explain the spurts. However it is not known that any long-term model is necessarily correct. On the other hand, an association of spurts with impacts and mass extinctions in time would be strong support for the hypothesis that comet showers are responsible for episodic disruption of the earth's climate, biota, and core dynamo.

The times at which the spurts begin can be estimated fairly accurately ($\pm$ 1 m.y.). The deviations of these times from the ages of impacts and mass extinctions are used to develop a parametric measure of asssociation. Nonparametric measures that take into account "missing" spurts and extinctions are also used. These measures are applied to simulated data as well as to the Harland et al. reversal data.

The results show that the reversal spurts are not associated demonstrably with extinctions or well-dated impacts. If the spurts do record episodes of intense bombardment of the earth, then the mass extinctions do not, in general, occur at times of impacts. Furthermore, the large impact craters we see are not obviously related to the spurts, suggesting that the craters may have been caused by bolides of a different nature and with a different temporal pattern. However, the most simple explanation seems to be that the spurts do not record comet showers, either because the recording mechanism suggested by Muller and Morris (2) is not effective or because comet showers are not triggered in the ways considered by Hut et al. (3).

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